KODAK MIN-R L Film System

User Guide

Kodak

KODAK MIN-R L Film System User Guide

The following information is intended only as a guide for troubleshooting the KODAK MIN-R L Film System; site specific conditions may cause different results. For optimum results, KODAK MIN-R Films, Screens, and Cassettes should be used as part of a system with KODAK Processing Chemicals and Equipment. If you have any questions concerning the information contained in this guide, contact your local Kodak representative or contact Health Imaging Technical Support at 1-800-336-4722 (716-724-9362) or on Kodak's Health Imaging Internet site: www.kodak.com/go/mammo.

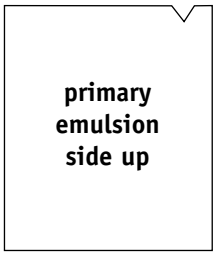
How to Use This Guide

The KODAK MIN-R L Film System User Guide includes the following sections to provide information and to help optimize image quality:

- Keys for Properly Processing KODAK MIN-R L Film
- Sensitometric Variability
- Optimizing Exposure
- Minus-Density Artifacts (Shadow Images/Pick-Off/ Processor Digs)
- A Method for Evaluating Film Performance in Other Manufacturers' Developer Solutions
- Fixer Considerations
- Drying
- Other Technical Considerations
- Troubleshooting Tools
- Uniformity of Screen Speed
- Information Needed by Kodak to Facilitate Troubleshooting

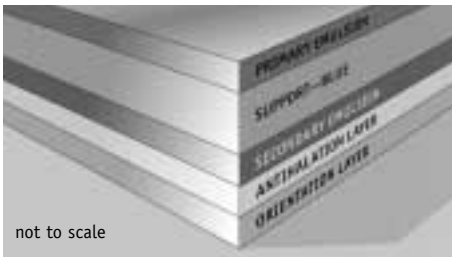
Description of KODAK MIN-R L Film

- KODAK MIN-R L Film for mammography was designed for radiologists who rate visualization of the breast periphery on par with high contrast in the breast parenchyma.
- KODAK MIN-R L Film has a novel double emulsion design, for use with standard, green-emitting, single-screen cassettes. Total system speeds are shown in the table below.
- KODAK MIN-R L Film is identified by a single V-notch. The primary emulsion is up when the notch is on the right hand side at the top edge of the film. The primary emulsion should be in contact with the screen during imaging.

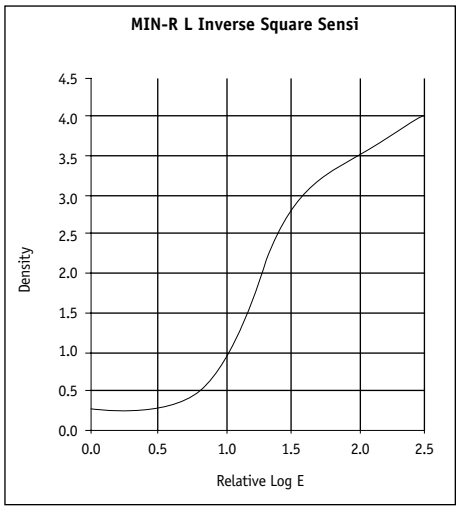


not to scale

- Kodak has added an orientation layer to the film to aid in the identification of the primary emulsion side; the dull side identifies the primary emulsion side of the film (the side which is to be placed against the screen during imaging).



- In documentation which refers to the emulsion side of the film, this should be considered a reference to the primary emulsion of KODAK MIN-R L Film.



Screen/Film Comparison Chart

KODAK Film	KODAK Screen	Processing Cycle	Relative Speed[1]	Contrast[2]	D-max
MIN-R L	MIN-R 2000	Standard	150	3.40 RP/3.60 EXII	>4.0
MIN-R L	MIN-R 2190	Standard	190	3.40 RP/3.60 EXII	>4.0
MIN-R L	MIN-R	Standard	100	3.40 RP/3.60 EXII	>4.0
MIN-R M	MIN-R	Standard	100	2.95 RP/3.15 EXII	3.9
MIN-R 2000	MIN-R	Standard	100	3.60 RP/3.80 EXII	>4.0
MIN-R 2000	MIN-R 2000	Standard	150	3.60 RP/3.80 EXII	>4.0
MIN-R 2000	MIN-R 2190	Standard	190	3.60 RP/3.80 EXII	>4.0

[1] Relative speed determined from matched-density radiographs of a mammography phantom; KODAK MIN-R M Film and MIN-R Screen arbitrarily assigned a relative speed of 100.

[2] Contrast—Measured as the average gradient between densities 0.25 and 2.00 above gross fog.

Keys for Properly Processing KODAK MIN-R L Film

- KODAK MIN-R L Film should be processed using a standard processing cycle; developer immersion time and developer temperature should be as specified by the processor manufacturer as equivalent to a standard cycle.
  - —Note that decreased, not increased, contrast will result if extended cycle processing is employed.
  - —The table below reflects standard cycle processing parameters for KODAK X-OMAT Processors; for other brands of processors, check with the manufacturer to ensure use of a standard cycle.
  - —The Troubleshooting Tools section of this guide contains information on using a time-in-solution (TIS) test tool to ensure the proper processing of KODAK MIN-R L Film (page 20).
- The processing environment must be properly initiated and the processor quality control program established according to regulatory guidelines.
  - —The addition of three ounces per U.S. gallon (3.8 liters) (25 milliliters per liter) of KODAK RP X-OMAT Developer Starter is required to achieve appropriate image quality.
- Contact your local Kodak representative or contact Kodak's Health Imaging Technical Support at 1-800-336-4722 (716-724-9362) to obtain the following service bulletins containing important processing information for KODAK MIN-R L Film via the Health Imaging FaxBack System:
  - —Service Bulletin No. 30 (December 1999 revision), *Processing Recommendations for KODAK X-OMAT Processors,* publication No. N-923, FaxBack document No. 800210
  - —*Conversion Instructions and Processing Recommendations for KODAK MIN-R L Film*

KODAK X-OMAT AND MIN-R PROCESSOR(S)	DEVELOPER IMMERSION TIME (APPROXIMATE)	DEVELOPER TEMPERATURE
M35, M35A, M35A-M, M20, and MIN-R Mammography Processor	33 seconds	92°F (33.5°C)
M7[3] and M7A[3]	27 seconds	92°F (33.5°C)
M7[4], M7A[4], M7B, 270 RA, and 3000 RA; XML 300	27 seconds	94°F (34.4°C)
M6B, M6-N, M6A-N, M6AW, 460 RA, 480 RA, and 5000 RA	25 seconds	95°F (35°C)
M8	21 seconds	96°F (35.6°C)

[3] KODAK X-OMAT M7 and M7A Processors with 140-second total processing time
[4] KODAK X-OMAT M7 and M7A Processors with 122-second total processing time

Sensitometric Variability

KEY **MD: Mid-Density (Speed)** **DD: Density Difference (Contrast)** **B + F: Base Plus Fog** **↑: Increasing** **↓: Decreasing** **→: No Change**

Note that only the combinations of MD, DD, and B + F presented in this guide typically occur due to the decreased sensitivity of KODAK MIN-R L Film to processing fluctuations. When MD, DD, and B + F differ greatly from expected values and/or indicate an out-of-control processing environment (e.g., reaching or exceeding ±0.15 of the operating levels for MD and DD), always generate another sensitometric strip, making sure that:

- The primary emulsion side of the film was toward the light source of the sensitometer.
- The temperature of the developer solution in the processor has stabilized before exposing and processing the sensitometric strip.
- The settings on the sensitometer were properly set (i.e., single-sided exposure, green, recommended DIP switches if the sensitometer is exposure adjustable, etc.).
- The film used was taken from the box set aside for processor quality control.
- The delay between exposing and processing the film is as normally occurs from day to day. (Note that immediate processing after exposure of the sensitometric strip by the sensitometer is recommended.)
- The same densitometer was used to measure MD, DD, and B + F values.
- The calibration of the densitometer is correct.
- If an automatic scanning densitometer is used, the correct channel was used and the programming has not been changed.

Compare MD, DD, and B + F results from the processing control chart to the information below to determine possible causes and corrective actions.

Trends in Graph	Possible Causes	Comments	Corrective Actions
MD: ↓ **DD: ↓** **B + F: ↑ or →**[5]	Severe under-replenishment	MD: ↓ severe DD: ↓ severe B + F: →	◆ Check for kinked or air-locked developer replenishment line ◆ Check for improperly mixed (overdiluted) developer replenisher —Check amount of water added ◆ Check developer replenishment rate ◆ Check that rate set as recommended in Service Bulletin No. 30 ◆ Check chemical usage ◆ Check for change in film volume since rate was set and adjust accordingly (raise) ◆ Communicate changes in film volume to processor service firm ◆ If EXII Developer is used, Contrast will increase just before dropping severely
	Major contamination of developer with fixer	B + F: ↑	◆ Call service to clean the processor —Drain developer tank —Thoroughly flush tank and developer rack with water —Change the developer filter ◆ Use splash guards ◆ Remove and insert the fixer rack carefully ◆ Process film with edges in contact with film feed tray guides to avoid film jam
	Severe oxidation of developer	B + F: →	◆ Always use a floating lid on top of the developer replenisher inside the replenisher holding tank ◆ Check developer replenishment rate ◆ Call service to check processor
	Exhausted developer	B + F: →	◆ Check developer replenishment rate ◆ Check that rate set as recommended in Service Bulletin No. 30 ◆ Check chemical usage ◆ Check for change in film volume since rate was set and adjust accordingly ◆ Communicate changes in film volume to processor service firm
	Expired film	DD: ↓ slight B + F: ↑ slight	◆ Check film expiration date ◆ Manage film inventory using first-in, first-out method
	Film stored above the recommended temperature and relative humidity	MD: ↓ slight B + F: ↑	◆ Store unprocessed/unexposed film and processed radiographs between 50 to 70°F (10 to 21°C) and 30 to 50% relative humidity

[5] Base Plus Fog values for KODAK MIN-R L Film are generally stable; ↑ or → may occur, as indicated in the "Comments" column; ↓ does not generally occur.

Trends in Graph	Possible Causes	Comments	Corrective Actions
MD: ↑ **DD:** ↑ **B + F:** →[5]	Slight contamination of developer with fixer	DD: ↑ slight	◆ Call service to clean the processor —Drain developer tank —Thoroughly flush tank and developer rack with water —Change the developer filter ◆ Use splash guards ◆ Remove and insert the fixer rack carefully ◆ Process film with edges in contact with film feed tray guides to avoid film jam
MD: ↑ **DD:** ↓ **B + F:** ↑ **or** →[5]	Developer temperature higher than recommended (within 5°F [3°C])	B + F: ↑ slight	◆ Measure developer temperature using accurate or calibrated thermometer ◆ Verify developer temperature set as recommended in Service Bulletin No. 30 for model of processor ◆ Lower thermostat to correct temperature ◆ Check thermostat and recirculation pump for malfunction ◆ Check water flow and temperature
	Water temperature higher than recommended (if developer temperature above set point)	B + F: ↑ slight	◆ Check temperature of incoming water ◆ Verify water temperature set as recommended in Service Bulletin No. 30 for model of processor ◆ Install mixing valve to regulate water temperature
	Developing time longer than recommended	B + F: ↑ slight	◆ Check immersion time using time-in-solution test tool
	Over-replenishment	MD: ↑ slight DD: ↓ slight B + F: ↑ slight	◆ Check Service Bulletin No. 30 for recommended rates, and adjust
	No starter added to fresh developer in processor developer tank	MD: ↑ slight B + F: ↑ slight	◆ Check Service Bulletin No. 30 for the amount recommended for the model of processor in use ◆ Add the correct amount of KODAK RP X-OMAT Developer Starter
	Insufficient amount of starter added	MD: ↑ slight DD: ↓ slight B + F: →	◆ Check Service Bulletin No. 30 for the amount recommended for the model of processor in use ◆ Add the correct amount of KODAK RP X-OMAT Developer Starter
MD: ↓ **DD:** ↑ **or** → **B + F:** →[5]	Developer temperature lower than recommended (within 5°F [3°C])	DD: →	◆ Measure developer temperature using accurate or calibrated thermometer ◆ Verify developer temperature set as recommended in Service Bulletin No. 30 for model of processor ◆ Raise thermostat to correct temperature ◆ Check thermostat and recirculation pump for malfunction ◆ Check water flow and temperature
	Water temperature lower than recommended (if developer temperature below set point)		◆ Check temperature of incoming water ◆ Verify water temperature set as recommended in Service Bulletin No. 30 for model of processor ◆ Install mixing valve to regulate water temperature
	Developing time shorter than recommended	DD: →	◆ Check immersion time using time-in-solution test tool

Sensitometric Variability (continued)

Trends in Graph	Possible Causes	Comments	Corrective Actions
MD: ↓ **DD:** → **B + F:** →[5]	Developer temperature lower than recommended (within 5°F [3°C])	MD only affected; ↓	◆ Measure developer temperature using accurate or calibrated thermometer ◆ Verify developer temperature set as recommended in Service Bulletin No. 30 for model of processor ◆ Raise thermostat to correct temperature ◆ Check thermostat and recirculation pump for malfunction ◆ Check water flow and temperature
	Water temperature lower than recommended (if developer temperature below set point)		◆ Check temperature of incoming water ◆ Verify water temperature set as recommended in Service Bulletin No. 30 for model of processor ◆ Install mixing valve to regulate water temperature
	Developing time shorter than recommended		◆ Check immersion time using time-in-solution test tool
MD: → **DD:** ↑ **B + F:** →[5]	Too much starter added (>50 percent)	DD only affected; ↑	◆ Check Service Bulletin No. 30 for the amount recommended for the model of processor in use ◆ Add the correct amount of KODAK RP X-OMAT Developer Starter ◆ Check Service Bulletin No. 30 for recommended rates and adjust
	Developer replenishment rate too low KODAK EXII Developer		
MD: → **DD:** ↓ **B + F:** ↑ **or** →[5]	Exhausted fixer (if film cloudy or exhibits dye stain [pink or lavender color])		◆ Check fixer replenishment rate ◆ Check that rate set as recommended in Service Bulletin No. 30 ◆ Check fixer replenishment line for kinks ◆ Check that fixer was properly mixed
	Fixer temperature lower than recommended (if film cloudy or exhibits dye stain [pink or lavender color])	B + F: ↑	◆ Measure fixer temperature using accurate or calibrated thermometer ◆ Verify fixer temperature set as recommended in Service Bulletin No. 30 for model of processor ◆ Raise thermostat to correct temperature
	Developer replenishment rate too high KODAK EXII Developer		◆ Check Service Bulletin No. 30 for recommended rates and adjust

Optimizing Exposure

KODAK MIN-R L Film is a novel mammographic film, extending the exposure latitude to allow the simultaneous visualization of peripheral structures with the parenchymal detail. In order to achieve the full benefits of this technology, and get the best images on the viewbox, it is important to optimize the exposure characteristics. The objective of this section is to review procedures that can help in the selection of the optimal optical density and preferred kVp. This can lead to the establishment of technique charts which are an important part of reliably achieving the optimal image quality in mammography.

There is no current optimal standard for a single level of contrast and optical density.

Preference and Regulation

The optimal kVp range and optical density depend upon several factors, including the *preference* of the radiologist(s) for contrast and optical density, the capabilities of the mammographic x-ray equipment, the light output of the viewboxes and control of extraneous light, etc.

It is also important to check existing local and national regulations/ guidelines as to whether any direction is given regarding optimal exposure for mammography. For example, a minimum mammographic phantom background optical density (O.D.) may be suggested, such as at least 1.50, and more important, minimum optical density for the glandular tissue on mammograms of dense breast tissue may be required. Radiologist reviewers of clinical films for the American College of Radiology Mammography Accreditation Program consider glandular tissue with an optical density lower than 1.0 under-exposed. It is important that all clinical and phantom images meet local regulations.

Preparation

In order to optimize exposure techniques, it is exceedingly important that a number of technical factors be understood and balanced. A medical physicist may be able to direct this assessment in consultation with the radiologist(s). Note that a physics survey, including kVp accuracy and AEC (automatic exposure control) reproducibility tests, should first be performed and the results judged satisfactory before doing any of the additional procedures discussed in this guide. The processor used for mammography must also be in control. (i.e., verify that the processor and processing environments are functioning according to the manufacturers' recommendations. This information is contained in Service Bulletin No. 30 (December 1999 revision), *Processing Recommendations for KODAK X-OMAT Processors,* publication No. N-923, FaxBack document No. 800210; and in *Conversion Instructions and Processing Recommendations for KODAK MIN-R L Film*. Both documents are available by visiting the Health Imaging Internet site (www.kodak.com/go/mammo), or by calling Kodak's Health Imaging Technical Support at 1-800-336-4722 (716-724-9362) to access the Health Imaging FaxBack System.

Viewing Conditions

The viewbox is an integral part of the mammographic imaging chain. It is essential for good viewing practices to be implemented to ensure optimal interpretation. The following factors should be considered:

- Evaluate the lightboxes for cleanliness, light output, and consistency; clean the interiors and surfaces of viewboxes, replace all lightbulbs, etc. *NOTE: All lightbulbs should be replaced whenever it is necessary to change one lightbulb.*
- The intensity for all viewing panels should be matched, both within and between viewboxes.
- It is recommended that the technologist/ radiographer viewboxes match the intensity of interpretation viewboxes to aid in ensuring adequate exposure.
- Use masking materials and equipment to control extraneous light.
- Control extraneous light within all viewing areas.
- Consult the instructions in the *Kodak Viewing Conditions Test Tool,* Kodak publication No. M7-207, CAT No. 150 1915.

kVp

The traditional rules of thumb for mammographic imaging have been that the lowest kVp be selected in order to achieve the highest possible subject contrast while maintaining an acceptable dose (e.g., less than 3.0 mGy [milligrays] [300 millirads]) and an exposure time of less than 2 seconds to reduce motion. The range of 24 to 28 kVp has typically been used worldwide. However, the use of higher kVp with KODAK MIN-R L Film may be acceptable.

All other things being equal:

- As kVp is decreased, the length of the exposure increases, which in turn increases the risk of motion on clinical films.
- As kVp is increased, the length of the exposure decreases.

Procedure #1 for assessing the effect of varying kVp on image quality:
The following procedure assumes satisfactory kVp accuracy and reproducibility.

1. Assemble the tools which will be needed:

- Mammographic phantom (e.g., phantom that adheres to the ACR mammographic accreditation phantom).
- Mammographic cassette of the type used clinically (ideally, the same cassette should be used for all exposures).
- Fresh box of mammography film (all images must be made using the same emulsion).
- Densitometer.

Optimizing Exposure (continued)

2. For each exposure, in the darkroom under appropriate safelighting, load a sheet of film into a clean mammographic cassette. If using an improved KODAK MIN-R 2 Cassette, wait at least 5 minutes prior to each exposure; wait at least 15 minutes prior to each exposure if using a KODAK MIN-R Cassette or an older version of the KODAK MIN-R 2 Cassette.

3. Prepare to make the first exposure:
- Place the cassette into the moving grid cassette holder of the mammographic unit.
- Position the phantom on top of the grid.
- Lower the compression device until it contacts the top of the phantom.
- Position the photoreceptor so it is centered underneath the phantom.
- The maximum exposure time of any image should not exceed some predetermined value, such as 2 seconds.

NOTE: The target optical density should be as typically used clinically. Each image in the following series should be within 0.05 of the target optical density.

4. Expose a series of phantom images varying the kVp by one kVp increments, from the lowest kVp to the highest (i.e., 24–30 kVp).

5. Prepare a mask for the images by exposing a 35 x 43 cm film to light, processing the film and cutting the mask and films to accommodate the images. *NOTE: Mask to the edge of wax insert. Tape the phantom images sequentially. Label each image with the kVp used (so it is either visible or hidden, as desired).*

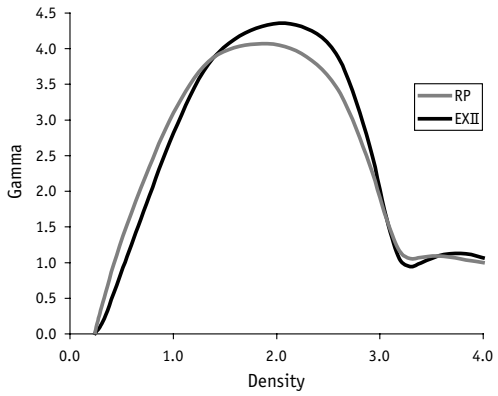
6. Place the masked phantom images (one or more series) on an illuminated viewbox used for mammography in a darkened room and view. Identify the image which shows the greatest amount of information (details). The kVp and optical density of the preferred image may indicate the best technique for the phantom on the specific piece of mammographic x-ray equipment used.

Contrast & Optical Density

Contrast can be determined in several ways using the information on a sensitometric strip. This information is usually plotted as contrast/optical density curve. A contrast/optical density curve is also known as a gamma plot.

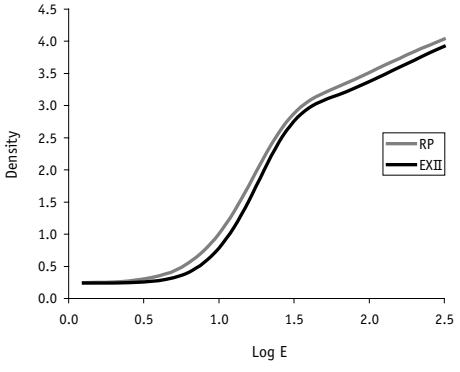
At the maximum of the contrast/optical density curve, the film is the most responsive to changes in exposure. In terms of optimum film contrast, the selected optical density would correspond to this point. Taking into consideration dose, length of exposure, viewing conditions and radiologists' preferences may result in a lower selected optical density than the maximum (2.0 in the above curve). Note, however, that the contrast/optical density curve in this example demonstrates highest contrast over a range of optical densities (1.45–2.2). A selected optical density within this range will still produce very high image quality. A lower preferred optical density may result in slightly lower contrast, but will provide more exposure latitude.

Contrast/Optical Density Curve



Contrast/optical density curves can be plotted manually, by using computer programs, or by using an automatic scanning densitometer with the capability of calculating the gamma, or contrast, anywhere on the characteristic curve. Such densitometers provide gamma value at 0.10 intervals. The characteristic curve and contrast/optical density curve (gamma plot) of a selected emulsion of KODAK MIN-R L Film (curves were generated for reference purposes using inverse square x-ray sensitometry), processed according to recommendations, are shown below. For the emulsion shown in this example, the highest contrast occurs between optical densities 1.45 to 2.2.

Characteristic Curve



Selecting Optical Density

Procedure #2 (using the same tools as in Procedure #1, page 7) for assessing if the optical density or densities tested above are optimal, i.e., provide the highest image quality:

1. Using the kVp of the preferred phantom image (Procedure #1), expose a series of phantom images using phototiming (automatic exposure control) and varying the density control setting. For example, make exposures using the –2, –1, 0, +1, and +2 settings on the density control. Aim for the background optical density of all phantom images to range from a minimum of 1.20 to approximately 1.80. Use the densitometer to check the actual optical density in the center of each image.

2. As done for the kVp series in Procedure #1, prepare a mask from an exposed and processed 35 x 43 cm film, mount the films sequentially, and label each image with the measured optical density.

3. Place the masked phantom images on the illuminated viewbox in a darkened room and view. Identify the image which shows the greatest amount of information (details). The optical density of the preferred image may indicate the best technique on the specific piece of mammographic x-ray equipment. In studying the images from your kVp and optical density series, notice that changing the kVp resulted in very little change to the radiographic contrast of the images, while changing the optical density resulted in the perception of significant contrast changes. Contrary to widely held beliefs, kVp has a minor influence on radiographic contrast when using a combination of molybdenum and rhodium for anodes and filters in mammography; however optical density has a major influence on contrast. (Radiographic contrast is a combination of subject and film contrast, and is defined as the difference in optical density, or film blackening, between areas of interest in a radiograph.)

The preferred kVp and optical density selected will also be based upon the light output and viewing conditions where the assessment took place. If viewboxes or viewing conditions are sub-optimal (i.e., low light output), as mentioned previously, the contrast and optical density preferred may not be consistent with regulatory requirements for image quality (images may be underexposed).

NOTES:

- *The above procedure will help establish the optimal kVp for the specific phantom which will simulate one specific breast thickness and type only. The facility should establish an optimal kVp range for different breast thicknesses and densities. The use of one kVp for all breast types is not recommended.*
- *Each mammographic x-ray unit should be evaluated.*
- *Consultation with the medical physicist or governmental agency regarding local/national dose regulations is suggested before making any permanent exposure technique changes.*

Exposure Time & Dose

Dose, and the length of the exposure in terms of minimizing motion on clinical films must also be considered with respect to the selected kVp and optical density. All factors should then be used to create technique charts; refer to page 10 of this guide for additional information.

After the optimal kVp and optical density have been determined by performing two procedures described above, assess whether local/national dose regulations can be met when that kVp and optical density are used for clinical images. If dose regulations cannot be met or a lower dose is desired, the use of a slightly higher kVp and/or of a slightly lower optical density may be used. Alternatively, a faster intensifying screen (i.e., KODAK MIN-R 2190 Screen) may be used.

Furthermore, it is necessary to assess the length of exposure time. In the recent past, exposure times of 3 to 5 seconds were common, especially for previous generations of mammographic x-ray equipment with three-phase, six-pulse and single-phase generators. Modern x-ray equipment usually employs high-frequency/constant potential generators which are more efficient. Motion is still a significant problem even if using modern equipment if long exposure times are used. To minimize motion, breast tissue should be adequately compressed, and all exposures should ideally last 1 to 1½ seconds, with 2 seconds generally considered the maximum.

Note that it may still be necessary for exposure techniques to last longer than 2 seconds when performing magnification views or when imaging dense breast tissue. A higher kVp setting and/or a faster intensifying screen, such as the KODAK MIN-R 2190 Screen, may be used to reduce long exposure times and motion during magnification or with very dense breast tissue. Additionally, any combination of factors in the imaging chain which results in an extremely low dose, e.g., less than 1.0 mGy (100 millirads), should be avoided. As total system speed increases above 200, noise increases and detail visibility decreases.

Reproducibility

The capabilities of the x-ray equipment to provide reproducible exposures (consistent optical density) when using a high-contrast screen-film combination must also be assessed. As the contrast of a screen-film combination increases, its **exposure latitude decreases**. If the optical density selected as preferred is positioned at the point of maximum contrast on the characteristic curve, exposure latitude is further decreased. In other words, the tolerance in the amount of exposure required to produce a desired density range decreases.

Optimizing Exposure (continued)

The exposure algorithms of older x-ray equipment when using the automatic exposure control (AEC) system may not be able to respond fast enough so that the proper optical density is obtained when a high contrast screen-film combination is used and/or the optical density preferred is at the point of maximum contrast. Achieving the desired optical density consistently is important for consistent image quality. If the optical density varies from image to image, the viewer generally perceives variable radiographic contrast. Modern equipment, when properly, is usually capable of consistently achieving the desired optical density on clinical images.

Practical Considerations

The goal for technologists/operators for all mammographic imaging should be to achieve a consistent optical density to avoid the misperception of variable image quality (changes in radiographic contrast).

Assume for a moment that processing is totally invariant and that all mammographic equipment in the facility has been calibrated using a specific emulsion of film, e.g., emulsion 104. When the phantom is exposed using the following:

- automatic exposure control,
- the designated cassette,
- emulsion 104 loaded into the cassette,
- the photocell (photoreceptor) in the ideal designated location,
- the preferred kVp, and
- the density control is set at "0" the preferred optical density (e.g., 1.60) is obtained on the processed film, and the exposure time is just under 2 seconds.

In this scenario, all clinical imaging should be done by varying the kVp as recommended in the technique chart while the density control setting is left at 0.

It has been common practice to move the density control setting (i.e., changing from "0" to a plus or minus value), especially when using older equipment whose phototiming algorithms could not properly compensate for reciprocity law failure as the length of the exposure increased. (The reciprocity law states that the optical density of a radiograph will be the same if the milliampere-seconds [mAs] is constant, regardless of mA; this law, however, applies to direct-exposure radiography and fails when intensifying screens are used, necessitating additional exposure in order to achieve the proper optical density.) If using modern equipment, significant improvements to phototiming algorithms have been implemented. Therefore, it is no longer necessary to change the density control setting, and doing so only results in changes in optical density and the perception of variable image quality and contrast.

When using a mammographic film that is high in contrast, such as KODAK MIN-R L Film, the window for achieving a properly exposed mammographic image is smaller, i.e., it has reduced exposure latitude and care must be taken in mammographic technique. In addition, when film with a different emulsion number is opened for clinical use, it may then be necessary to make a slight adjustment in the density control setting in order to achieve the proper optical density on all clinical images.

Technique Charts

It will be necessary to generate technique charts for each piece of equipment. Technique charts, generally used with automatic exposure control where the kVp is selected by the technologist/operator, should indicate how the kVp is altered from that used on the mammographic phantom as the breast thickness and density changes. Slightly lower kVp should be used for breasts compressed thinner than the phantom; slightly higher kVp should be used for breasts compressed thicker than the phantom. Technique charts should also include reference to different target and filter combinations if used for different breast thicknesses and/or density. In all cases, the kVp selected for any particular exposure should allow that exposure to be completed without exceeding the maximum desirable length of time.

In many circumstances, regulatory requirements stipulate that technique charts be posted on each piece of equipment. Note that even if using a fully automatic exposure control system, technique charts showing the appropriate program(s) should also be posted on each piece of equipment. (Refer to the manufacturer of the equipment as to their recommendations for choosing the correct program for specific screen-film combinations and technical parameters. It is very important that all types of mammographic x-ray equipment be initially calibrated for a new screen-film combination.)

All technologists/operators should be trained on the use of the technique charts and on any differences associated with the use of a different screen-film combination. It is important to note that as technology changes occur, different practices may be not only necessary but absolutely critical to obtain optimal image quality. In particular, higher kVp or different technical parameters than used previously with lower contrast screen-film combinations may be appropriate.

Other Tips

- Be as precise as possible when positioning the patient and the photocell (photoreceptor).
- Ensure that adequate compression is employed.
- Installation of new film should be accompanied by mammographic x-ray equipment calibrated by qualified personnel.
- A medical physicist should be consulted with any questions, or for any help with this procedure.

Minus-Density Artifacts (Shadow Images/ Pick-Off/Processor Digs)

Minus-density artifacts are those which appear white or lighter than the surrounding background. They are of particular concern in mammographic imaging due to the use of single screen.

Minus-density artifacts may be caused by handling or processing (i.e., processor digs). The most frequently occurring minus-density artifact, however, is termed shadow images. Shadow images are caused by dirt and dust superimposed inside the cassette between the intensifying screen and film emulsion. Shadow images appear as small, random, minus-density spots on the film, and are frequently confused with pick-off or processor digs. It is estimated that shadow images may account for as much as 95 percent of minus-density artifacts seen on mammographic images.

Controlling shadow images is dependent upon:

- Thoroughly cleaning the surface of intensifying screens and cassette interiors as recommended.
- Periodically cleaning the interiors of film magazines and roomlight film handling devices, such as the KODAK X-OMAT Miniloader 2000.
- Proper darkroom hygiene.

The high contrast of KODAK MIN-R L Film, however, may increase the visualization of minus-density artifacts, necessitating even more care in maintaining a clean darkroom environment and clean intensifying screens and cassettes.

Cleaning Mammographic Intensifying Screens

Maintaining clean mammography intensifying screens and cassette interiors will reduce the occurrence of minus-density artifacts caused by dust or dirt. Intensifying screens and cassettes should always be cleaned following the recommendations of the manufacturer. Generally, for effective cleaning prolonged screen life, only the screen cleaning solution (e.g., KODAK MIN-R Screen Cleaner) and any other products specified by the manufacturer of the screens and cassettes should be used.

Mammography screens should be cleaned at least once a week, or more frequently as needed to reduce shadow images caused by dust and dirt. (If it is necessary to clean the screens more often than once a day, attention to the darkroom environment itself may be necessary; refer to page 12 of this guide for information on troubleshooting the darkroom).

For best results, the recommendations below should be followed when cleaning KODAK MIN-R and MIN-R 2 Cassettes in which KODAK MIN-R, MIN-R 2000, or MIN-R 2190 Screens are mounted. New screens and cassettes must be cleaned prior to first use:

1. Chose a clean location to clean screens and cassettes.

- If working on a countertop in the darkroom used for processing mammography film, wipe the outside of the cassettes and clean the countertop with a damp cloth prior to cleaning the screens.
- Manage cassettes so they are empty at the time of cleaning (end of the day is usually best).
- Avoid replacing film previously loaded into cassettes back into the film box or film bin, since this could introduce dust into the film supply.

2. Clean the inside plastic cover of the cassette (tube side panel) using a lint-free wipe that has been dampened with a small amount of the KODAK MIN-R Screen Cleaner.

3. Dry the cover. It may be advisable to use a camel's-hair brush or other soft lint-free brush to remove any dust accumulated in the corners of the cassette cover and along the hinge. Such dust may not be easily reached with the dampened cloth.

4. Moisten a lint-free wipe with a small amount of KODAK MIN-R Screen Cleaner and gently rub the wipe across the screen.

- Avoid the use of abrasive wipes such as surgical gauze pads.
- Avoid excessive pressure or rubbing on the screen.
- Avoid pouring the screen cleaner directly onto the screens or cassettes.
- Use the minimum amount of screen cleaner needed to moisten the wipe. Excess screen cleaner will not improve screen cleanliness, will prolong the drying period, and may stain the screen.
- Clean around any labels on the screen (e.g., those used to individually number the cassettes).
- DO NOT WIPE THE SCREEN DRY. Allow the screen surface to air dry so that the full effects of the screen cleaner may be realized.
- A solution of 70% isopropyl alcohol may be used occasionally to remove stubborn dirt or dust.
- After using 70% isopropyl alcohol, KODAK MIN-R Screen Cleaner must be used following the procedure outlined above. **The use of 70% isopropyl alcohol should be limited to occasional use only.**

5. Stand the cassettes on edge to dry.

- Allow the screens and cassettes to completely air dry before returning them to service.
- Loading film into a cassette with wet screens may damage the film and lead to staining of the screens.

6. Inspect the screen and cassette cover for any stray particles of dust.

- An ultraviolet, or black, light is helpful in determining if screens and cassettes are clean.
- Limit exposure to the ultraviolet light and observe appropriate safety precautions for eyes, face, and exposed skin: do not look directly at the light.

Minus-Density Artifacts (Shadow Images/ Pick-Off/Processor Digs) (continued)

7. Reload the cassette with film.
- If using improved KODAK MIN-R 2 Cassettes, wait at least 5 minutes after loading before using.
- If using KODAK MIN-R Cassettes or an older version of KODAK MIN-R 2 Cassettes, wait at least 15 minutes before using.

NOTE: Improved KODAK MIN-R 2 Cassettes have a rounded latch lever. The older version of the cassette has an angular latch lever.

8. Reclean the countertop, if the cleaning procedure was done in the darkroom.

9. Between regular cleanings, a camel's-hair brush may be used to remove dust particles from the cassette and screen surface. Care should be taken when using any brush to protect the screen surface from scratches, which will degrade image quality.

10. Each intensifying screen and cassette should be marked with a unique number to facilitate locating a specific cassette suspected of requiring cleaning or inspection.

Troubleshooting the Darkroom

When initiating a quality assurance program, the darkroom should be checked for any significant factors which may contribute to shadow images. After addressing any outstanding issues, properly cleaning intensifying screens used for mammography as discussed above will generally control shadow images satisfactorily. In some circumstances, it may be necessary to thoroughly troubleshoot the darkroom for dirt and dust. Consider the following suggestions which are intended to help reduce airborne dust, dirt, and lint from the environment, and make the darkroom easier to keep clean:

Perform initially:
- Clean screens and cassettes at least weekly.
  - —Clean screens and cassettes more frequently (e.g., daily), if necessary.
- Ensure that film magazines and roomlight film handling equipment are cleaned periodically, if used.
- Use an ultraviolet, or black, light to help identify sources of dust and dirt in the darkroom.
  - —Note that all dust particles do not fluoresce under ultraviolet illumination.
  - —Limit exposure prudently and observe appropriate safety precautions for eyes, face, and exposed skin; do not look directly at the light.
  - —Do not expose film to ultraviolet light.
  - —Use the light again after cleaning.

Perform daily:
- Damp mop darkroom floors to remove any dust that settled overnight.
- Clean darkroom countertops using a lint-free wipe and appropriate non-residual cleaner.
- Clean the processor film feed tray last.
  - —Moisten a lint-free wipe with a small amount of KODAK MIN-R Screen Cleaner used for intensifying screens.
  - —If the feed tray needs to be cleaned more frequently, use the ultraviolet light to check the cleanliness of the incoming air.

Perform occasionally:
- Wipe darkroom walls, the fronts of cabinets, safelights, vent surfaces, exposed pipes, etc., with a damp lint-free wipe periodically to eliminate clinging dust.
- Vacuum or use a damp lint-free wipe to remove dirt and dust from the inside of the film bin occasionally (e.g., once a year, or as needed).
- If passboxes are used, check the insides for paint particles, metal flakes, etc.
  - —Clean periodically.

Institute good practices:
- Maintain relative humidity between 30 and 50 percent to minimize the attraction of particles onto films and intensifying screens.
- Do not routinely place mammography cassettes on the floor.
- Dirt may be carried into the darkroom along with the cassettes.
- Filter air coming into the darkroom, either at the system level, or by placing furnace-type filters in the air vents feeding the darkroom.
  - —Change air filters according to the frequency recommendations of the manufacturer.
  - —Electrostatic air cleaning devices may be helpful if a significant dust problem exists in the darkroom.
- Locate ventilation louvers in darkroom doors near eye level, not near the floor, and vacuum or wipe periodically.
  - —Use a vacuum cleaner in the darkroom only if the dust particles that could be stirred up from the vacuum exhaust have enough time to settle (e.g., overnight).
  - —Then clean the countertops, floors, and film feed tray.
- Contain dust from any new construction in or near the darkroom.
  - —Avoid drywall dust accumulation in vent pipes during construction or long-term dust/shadow image problems may result.
  - —Thoroughly clean vents before access is limited.
  - —Avoid installing any new equipment, such as a roomlight processor, in an area still under construction.
- Minimize storage in the darkroom.
- Open cases of film and other corrugated cardboard boxes outside the darkroom and carry the contents inside to reduce introducing additional cardboard fibers into the darkroom.
- Open new boxes of film slowly and carefully to reduce cardboard fibers from becoming airborne.
- Remove the flap and box top from the darkroom after placing the film (in its envelope and box) in the film bin.

- Remove the stiffener cardboard from film boxes and the darkroom.
- If the film is packaged in a sealed, foiled-lined paper envelope, use a pair of scissors to cut the envelope to reduce airborne fibers.
  —Do not remove the film from the envelope or store loose film in the box, film bin, or film safe at any time.
- Avoid replacing unexposed film that has been inside a cassette back into the film supply in the film bin.
  —This could introduce additional dust into the film bin and into the film supply.
- Switch from an identification (ID) printer or camera located in the darkroom to a camera located outside or to an ID-capable mammography unit to eliminate fibers from the thin paper cards inserted into the printer or camera in the darkroom.
- Eliminate non-essential items that contribute to dust and paper fiber.
  —Newspapers, magazines, facial tissue, notebooks, paper pads, etc.
- Require all darkroom personnel and technologists to wear lint-free clothing or to wear smocks or lab coats over clothing.
- Avoid hanging or storing articles of clothing in the darkroom.
- Avoid bringing materials that shed fibers into the darkroom (e.g., knitting).
- Avoid washing machines and dryers in the darkroom.
- Thoroughly clean the entire darkroom if it is necessary to clean screens and cassettes more frequently than once a day.

Evaluate darkroom features:

- Darkroom ceilings should preferably be solid, if possible, smoothly finished and painted.
  —Suspended ceilings, especially in darkrooms with a single door entrance, may be a significant source of dirt and dust.
  —Slamming the darkroom door can cause suspended ceiling tiles to move and dust to sift down from the tiles and dead space above the ceiling.
  —It may be helpful to seal tiles to the suspension frame to prevent ceiling tile movement when the darkroom door is closed (slammed); this should be done only if there is no periodic need for access to the area above the ceiling.
  —It may also be helpful to seal the surface and edges of the ceiling tiles themselves to decrease/eliminate airborne particles from the tiles; check with the ceiling tile manufacturer for an appropriate sealant (e.g., semi-gloss paint or polyurethane) and with local authorities to ensure that sealing the tiles in any manner does not violate local fire codes.
  —If access to the area above the suspended ceiling is required, securely tape a large continuous sheet of plastic over the ceiling to contain the dust; it may easily be removed when access is necessary.
  —Install a revolving (barrel-type) door to eliminate door slamming/dust sifting down from the ceiling and to improve traffic flow into and out of the darkroom.
  —Check the felt installed as part of revolving doors as it may be an additional source of lint.
  —If the darkroom is old (i.e., constructed many years ago), check all materials used in the ceiling for brittleness and replace, if necessary.
- Darkroom walls should be smoothly finished, painted using a light-colored semi-gloss paint, and clean.
  —Walls painted with semi-gloss paint are easier to keep clean.
  —The use of a light-colored paint maximizes safelight illumination and makes it easier to accomplish all tasks performed in the darkroom.
  —Avoid flat paint because dust can cling more easily to walls and they are difficult to wash.
  —Repaint walls with peeling paint.
- Replace any open shelving.
  —No open shelving of any kind should be used, especially above darkroom countertops.
- Install cabinets with doors to reduce areas that may accumulate dirt and dust.
  —Use cabinets that reach all the way to the ceiling for upper storage.

Minus-Density Artifacts (Shadow Images/ Pick-Off/Processor Digs) (continued)

Processor Digs/Pick-Off Marks

Appearance:
Pick-off marks/processor digs appear as very small minus-density spots on the film where the emulsion has been removed down to the film base. Often the piece of the emulsion that is removed may be deposited on the film near the trailing edge of the minus-density mark or may be deposited randomly on the film. Pick-off marks are most apparent on single screen images. Pick-off marks are most visible in transmitted light. Unlike shadow images, pick-off marks can be seen in reflected light.

Pick-Off Marks

Direction of Travel

Causes:
- Rough/dirty rollers
- Varying transport speed
- Inactive processing chemicals
- Inadequate film/emulsion formulation

Remedies:
- Do the periodic maintenance procedures as outlined in the Service Manual.
- Mix new processing solutions.
- Check the surface finish of the knurled rollers for excessively sharp or rough areas. If necessary, install new rollers.
- Check the replenishment rates for the developer and fixer solutions.

Red Grease Pencil Test to Determine Source of Minus-Density Artifacts

Tools required:
- Film with minus-density artifacts
- Red grease pencil
- Lint-free wipe (used for screen cleaning)

Procedure:
1. On the primary emulsion side of the film, use the red grease pencil color in all the minus-density spots that are of concern.
2. Take the wipe and gently clean away the red grease pencil marks from all the spots colored.

Analysis:
1. The minus-density spots that are cleaned of red grease pencil marks are shadow images caused by dust/dirt.
2. The minus-density spots that DO NOT clean and remain red are caused by processor digs/pick-off.

A Method for Evaluating Film Performance in Other Manufacturers' Developer Solutions

The United States Food and Drug Administration (FDA) Mammography Quality Standards Act (MQSA) Final Regulations, effective April 28, 1999, states that processing be capable of developing films in a manner equivalent to the minimum requirements specified by the film manufacturer. It is likely that compliance guidance from the FDA will recommend that facilities have documentation from the film or chemical manufacturer to support this.

To determine if another manufacturer's developer is within Kodak's acceptable range for KODAK Mammography Films, you will need to have access to a processor using fresh KODAK RP X-OMAT Developer and Replenisher or KODAK X-OMAT EXII Developer with the appropriate amount of KODAK RP X-OMAT Developer Starter for the type of film to be tested.

NOTE: This procedure will take from 2 to 4 hours to perform. Do not attempt to perform this test unless both developers will be tested within that time frame on the same day. This test can best be performed using components of the complete KODAK System; i.e., processors and cassettes.

Items Needed

1. A calibrated Sensitometer/ Densitometer (similar to KODAK Process Control Sensitometer/Densitometer) that accurately reads above 4.0 O.D. (optical density).

2. Calibrated Digital Thermometer.

3. Stopwatch.

4. A box of KODAK MIN-R L Film.

5. Freshly mixed KODAK RP X-OMAT Developer and Replenisher or KODAK X-OMAT EXII Developer Replenisher and a bottle of KODAK RP X-OMAT Developer Starter.

6. Freshly mixed other manufacturer's developer replenisher and a bottle of that manufacturer's starter.

Setup, Exposure, and Processing the Film

Information to complete steps 1–4 can be found in Service Bulletin No. 30 (revised December 1999), available by calling Health Imaging Technical Support at 1-800-336-4722 (716-724-9362).

1. Fill the processor with KODAK RP X-OMAT Developer or KODAK X-OMAT EXII Developer Replenisher) and Replenisher, adding Kodak's recommended amount of starter for the mammography film to be used.

2. Using the calibrated thermometer, verify that the developer temperature is set as per Kodak recommendations.

3. Set the developer and fixer replenishment rates to Kodak's recommendations for processor type and film.

4. Measure the drop time for an 18 x 24 cm film and verify that the transport speed is set accurately.

5. Set the sensitometer for green sensitivity. For KODAK MIN-R L FILM, be sure that the primary emulsion side faces the light-exposing source.

6. Expose three films.

7. Process the film on the right-hand side of the feed tray, primary emulsion side down.

8. Label all films. Indicate developer used, date, time, and any other relevant information. Drain the developer solution, change the developer filter, and thoroughly rinse the tank, rack and developer-to-fixer crossover assembly. Repeat steps 1–8 using the other manufacturer's developer. Use the developer manufacturer's recommended starter and replenishment volumes.

Evaluating the Films

1. Read the films using the calibrated scanning densitometer. Note the speed value (step closest to 1.0 above gross fog) and the average gradient.

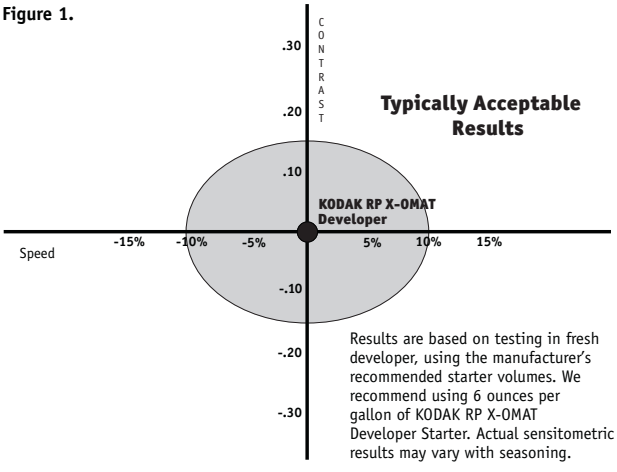
2. Average the speed and average gradient for the three films processed through KODAK Developer. Repeat for the films processed through the other manufacturer's developer.

3. Compare the speed and average gradient for the film processed in the other manufacturer's chemistry to that in KODAK RP X-OMAT Developer and Replenisher or KODAK X-OMAT EXII Developer Replenisher. Typically acceptable results are within the ellipse shown in Figure 1. This ellipse is defined by:

- a maximum range of ±10% in optical density at the speed step
- ±0.15 for average gradient of the films processed through KODAK Developer.

To verify adequate developing, the optical density of the 21st step should be measured. If the optical density is lower than 4.0 (for KODAK MIN-R-L Film with KODAK RP X-OMAT Developer), the test should be declared invalid. Other factors could affect the validity of the test. Please consult Kodak if you have questions.

Figure 1.



Results are based on testing in fresh developer, using the manufacturer's recommended starter volumes. We recommend using 6 ounces per gallon of KODAK RP X-OMAT Developer Starter. Actual sensitometric results may vary with seasoning.

Fixer Considerations

Assessing the Results of the Fixer (Hypo) Retention Test

A fixer (hypo) retention test should be performed regularly, i.e., at least quarterly, to make sure mammography films are properly washed and retain a minimal amount of fixer. Excessive fixer retention by the film may result in image degradation over time. It would then be of less or no value when making comparisons with subsequent mammographic studies. The procedure is outlined in the instructions included in the Hypo Retention test kit.

It is important to note the following points regarding assessing the results of the test:

- The Hypo Test Solution must be applied to the primary emulsion side of KODAK MIN-R L Film. (There should be no hypo retention in the secondary emulsion.)
- The KODAK Hypo Estimator, the test tool used to estimate the amount of retained fixer, or hypo, on processed radiographs, contains four colored sections (1–4) which indicate the estimated grams of thiosulfate ion per square meter of film, 0.01, 0.02, 0.05, and 0.12, respectively.
- The KODAK Hypo Estimator is a generic test tool for use with all types of photographic papers, films, and processed radiographs.
- The color of the test spot on KODAK MIN-R L Film may differ in color from the patches printed on the estimator, making it difficult to judge which color patch most closely matches the test spot.
  - —A yellowish, greenish, or brownish tone may result.
- To minimize the difficulty in making a visible or subjective comparison, use a spot-reading densitometer to make optical-density measurements.
  - —Make the first measurement after laying the clear central portion of the estimator in its plastic sleeve over the damp spot on the film.
  - —Make at least two additional measurements through the color patches on the estimator, the plastic sleeve in which the estimator is enclosed, and a clear portion of the film.
  - —The optical-density reading which comes closest to the reading taken from the test spot indicates the best match.
- The test spot should not be darker than the third patch on the estimator, indicating approximately 0.05 grams of retained fixer per square meter of film.

Other important points include:

- Perform the fixer retention test in normal lighting conditions (avoid bright light or sunlight).
- Perform only on a freshly processed film, or one that has been processed no more than two weeks previously.
- The shelf life of the test chemicals is approximately two years, assuming the chemicals have been properly stored with the cap tightly closed, within the required environmental temperature range, etc.
- Process another film and repeat the test if failing results are obtained.
- If failing results are obtained after repeating the test, consider replacing the test solution first if the solution is older than two years (or its age is unknown), if the conditions under which it has been stored are unknown, or if it is possible that the cap on the bottle may not always have been tightly closed.
  - —When purchasing a new bottle of test solution, write the date it is first opened on the bottle.
- If failing results are obtained after repeating the test, and the test chemicals are not in question, contact the processor service company or your local Kodak representative.

Dye Stain

Following the film manufacturer's recommendations for fixer in terms of type, replenishment rates, etc., is just as important as for developer since mammography films may be more difficult to clear and image stability storage requirements are longer.

Additionally, systematic replenishment rate reduction to minimize costs and environmental impact, and fixer reuse have become more prevalent. In some processing situations, KODAK MIN-R L Film may exhibit dye stain. Dye stain may be recognized by a general pinkish or lavender tint in a D-min area of the film.

Dye stain may be more pronounced in the following situations:

- A combination of electrolytic silver recovery with reduced fixer replenishment rates.
- The use of fixers exhibiting a high pH and/or high hardener level. (Note: It is normal for the pH of to increases with seasoning; increasing the fixer replenishment rate may help control the pH.)

It may be possible to reduce dye stain by:

- Checking that the fixer has been properly mixed.
- Increasing the fixer replenishment rate.
- Verifying that the film is being processed in the appropriate cycle.
- Checking the temperature of the fixer solution in the processor, and increasing to approximately 5°F (3°C) above the developer temperature, if possible.
- Checking the temperature of the wash water in the processor, and increasing, if possible. (Refer to Service Bulletin No. 30, revised December 1999, for general processor information.)
- If using electrolytic silver recovery, increasing the fixer replenishment rate and lowering the fixer pH by adding acetic acid. (Contact Health Imaging Technical Support at 1-800-336-4722 [716-724-9362] for additional information.)
- Considering use of a different method of silver recovery.

Drying

The last step in processing an x-ray film is drying. Drying prepares the film for handling, viewing, and storage. The physical characteristics of KODAK MIN-R L Film should allow for good drying.

A blower in the processor supplies heated air to the dryer section. Most of the warm air is recirculated; the rest is vented to prevent buildup of excessive humidity in the dryer. Proper processor ventilation is important to achieve proper film drying and decrease surface-pattern, or drying, artifacts. Refer to: Service Bulletin No. 101 (October 1992), *Dryer Venting Requirements for All KODAK X-OMAT Processors,* publication No. N-923, FaxBack document No. 800220.

The dryer temperature should always be set as low as possible while still being consistent with good drying. Use of a lower setting will also result in energy savings for processor operation.

The dryer temperature should never exceed the film manufacturer's recommendations.

A common tendency is to raise dryer temperature higher than recommended, especially in response to films not thoroughly dried, or still tacky, exiting the processor. Over-dried films usually exhibit severe drying artifacts that are visible on transmitted light as well as on reflected light.

For these circumstances, check the quality of the chemicals, both developer and fixer, and that replenishment rates and processor ventilation are appropriate. (Chemical quality and adequate replenishment rates are important not only for image quality but also for proper drying and film transport.) Drying artifacts visible with transmitted light and other drying problems can usually be eliminated or significantly improved when these areas are corrected.

Note that drying or surface patterns that are visible only on reflected light are not artifacts; they are considered normal and acceptable. When the film surface is closely examined in reflected light (the primary emulsion side of KODAK MIN-R L Film), slight drying patterns close to the film edges may be visible when the film has been properly dried using the lowest setting as recommended.

To troubleshoot drying problems, review the following causes and implement the solutions, as necessary.

Causes:

- Depleted, oxidized, or poor-quality processing chemicals.
- Poor squeegee action at the wash rack exit or entrance to squeegee.
- Clogged, missing, or out-of-position dryer air tubes; non-uniform or excessive airflow in dryer.
- Inadequate processor venting.
- Excessively high dryer temperature.
- Very cold wash water.

Solutions:

- Replace processing chemicals with fresh solutions.
  - —Check replenishment rates and adjust according to the film manufacturer's recommendations.
  - —Use processing chemicals recommended by the film manufacturer.
- Adjust or replace the wash rack exit squeegee.
- Replace/clean air tube(s).
- Check processor ventilation.
- Reduce dryer temperature to minimum required to produce dry films.
- Provide wash water within the recommended temperature range.

All actions suggested under "Solutions" should be done by the most appropriate person, that is, one who has received the proper training to perform the necessary task.

Other Technical Considerations

Evaluating Processors for Uniformity

Processors in which MIN-R L Mammography Film will be processed should be evaluated initially to determine whether films should be processed primary emulsion side up or primary emulsion side down which orientation provides the best uniformity and the fewest artifacts before processing clinical and quality control films.

Film must be processed primary emulsion side down in the X-OMAT M-35AM, X-OMAT M-35M and MIN-R Mammography Processors. (Multiloaders may be excluded as film orientation during processing is fixed.) The following procedure may be used to make this evaluation:

- Expose films to an optical density of 1.10 to 1.50, using the same cassette and a 1-inch thick uniform sheet of acrylic.
  - —The exposure time used should be at least 0.5 seconds or longer.
  - —The cassette should be known to have good screen-film contact.
- Lay the film on the film feed tray in the darkroom, and mark an arrow (↑) on the corner of the film with a lead pencil immediately before processing to indicate the direction of film travel.
  - —It is also helpful to mark the emulsion orientation (up [U] or down [D]), as well as which side of the processor feed tray (right [R] or left [L]) is being used, when feeding the film into the processor, e.g., ↑UR.
- Process one film so that the narrowest dimension of the film is the leading edge; process a second film so that the widest dimension of the film is the leading edge.
  - —To thoroughly evaluate the entire processor, up to eight films should be exposed and processed as described above: one pair primary emulsion up on the right side of the film feed tray, one pair primary emulsion up on the left side of the feed tray, one pair primary emulsion down on the right side of the film feed tray, and one pair primary emulsion down on the left side of the film feed tray.
- Expose the first two film pairs which will be processed as described above (primary emulsion up on right, primary emulsion up on left) using the small moving grid device (18 x 24 cm bucky) and use to evaluate whether artifacts are being generated by the x-ray unit in conjunction with the small bucky.
- Expose the third and fourth film pairs which will be processed as described above (primary emulsion down on right, primary emulsion down on left) using the large moving grid device (24 x 30 cm bucky) and use to evaluate whether artifacts are being generated by the x-ray unit in conjunction with the large bucky.
- Once processed, view the film pairs (or single films) in the same orientation as processed.
  - —Artifacts that are parallel to each other on a film pair occurred in the processor (artifacts may be parallel or perpendicular to film travel).
  - —Artifacts that are perpendicular to each other on a film pair occurred during exposure from the x-ray unit.
- Careful analysis of all of the films will indicate whether the primary emulsion up or down gives the best overall processing results.
- The protocol should subsequently be posted in the darkroom so all films are processed consistently.
  - —All clinical images, sensitometric strips, and phantom images primary emulsion up or all primary emulsion down.
- Films should be processed on both sides of the processor to prolong roller life.
- Quality control films (phantom images and sensitometric strips) should also be processed in a specific location with respect to the film feed tray (right side or left side, with the edge of the film butted against the guide of the film feed tray.

Processing Nonuniformity with KODAK MIN-R L Film

Processing nonuniformity, characterized by uneven optical densities on radiographs, may occur when KODAK MIN-R L Film is processed primary emulsion side up in the following processors: KODAK X-OMAT M35A-M, M35-M, M35, M35A, MIN-R Mammography Processor, 270 RA, and 3000 RA Processors. The nonuniformity occurs due to the accumulation of processing by-products adjacent to the film emulsion inside the developer rack. Besides nonuniformity, the characteristic curve plotted from the information from a sensitometric strip may also reflect nonuniformity at approximately 2.20 to 3.00 optical densities.

Due to nonuniformity, **processing KODAK MIN-R L Film primary emulsion side down is recommended in the processors noted above.** This allows developer solution to reach the primary emulsion more efficiently, reducing the occurrence of nonuniform development. Additionally, it is necessary to install smooth guide shoes in the developer rack to reduce guide shoe marks accentuated by processing film with the emulsion side down. Refer to *Conversion Instructions and Processing Recommendations for KODAK MIN-R L Film* for information on guideshoe kits for specific processors. Contact your local Kodak representative, visit Kodak's Health Imaging Internet site (www.kodak.com/go/mammo), or contact Health Imaging Technical Support at 1-800-336-4722 (716-724-9362).

The Darkroom Fog Test

The darkroom fog (safelight) test should be performed at least semi-annually. Several factors can affect test results.

- **Expose the phantom test film to the appropriate optical density.**
  The film should be exposed to an optical density of between 1.2 and 1.5. This density range is appropriate regardless of the optical density used for other phantom tests. Adhering to this density range is especially important for high-contrast mammography films such as KODAK MIN-R L Film.
- **Use the appropriate safelight filter.**
  A KODAK GBX-2 Safelight Filter, or equivalent, is the correct safelight filter for all KODAK Mammography Films.
- **Change the safelight filter periodically.**
  Safelight filters can fade and crack with age. Heat from incandescent bulbs can crack safelight filters over time.
- **Install the safelight filter correctly.**
  Filters should be installed so that the identification printing can be read when looking at the lamp. If the filter orientation is reversed, excessive heat buildup inside the lamp housing may cause the dye layer to crack and thus leak unsafe light.
- **Use the appropriate wattage bulb.**
  Oversized bulbs can damage the safelight filter from excessive heat. A 7.5 watt incandescent bulb is recommended for all KODAK Mammography Films.
- **The distance** of the safelight from the work surface and the direction of the light to the work surface can affect results. Also consider directing the safelight toward the ceiling.
- **Use the appropriate number of safelights for the size of your darkroom.**
  In large rooms with white ceilings, place no more than one lamp for every 64 square feet (6 square meters) of ceiling area. You can use a number of safelight fixtures (with the correct filter and bulb) if they are at the proper distance from the work surface and are placed at least 8 feet (2.5 meters) apart.
- **Check for other sources of fog.**
  Sometimes fog arises from exposure to light other than from safelights. Sources to consider are light leaks around doors, cracks in walls, or cracks where ceiling partitions join walls. Occasionally, automated processors will vibrate sufficiently to cause small openings between the light seals and the adjoining partition or the processor cover may not be tightly closed. Also, afterglow from some types of fluorescent lights can cause fogging. Glowing lights or dials on equipment located in the darkroom can fog film.

Grid Lines

Reciprocating or moving grids are commonly used for screen-film mammography. The visualization of grid lines or of the surface texture on top of the grid device may be more pronounced because of the improved image detail visibility and high contrast of KODAK MIN-R L Film. Refer to the table below for possible causes and corrective actions.

Possible Causes of Grid Lines	Corrective Actions
Low kVp used, resulting in long exposure times (longer than maximum time recommended by equipment manufacturer)	Use higher kVp to shorten exposure time —All exposure times should meet minimum and maximum time specifications
High kVp used, resulting in short exposure times (shorter than minimum time recommended by equipment manufacturer, e.g., 0.5 seconds)	Use lower kVp to lengthen exposure time —All exposure times should meet minimum and maximum time specifications
Mechanical problem with grid —Grid did not move or moved too slowly	Check electrical connection Make sure grid device is stable Make sure nothing is interfering with smooth passage of grid during each exposure Check with the equipment manufacturer or service
Older grid technology	Check with the equipment manufacturer about the availability of modifications to the existing grid or new grid technology

Troubleshooting Tools

Some simple but very effective tools are available for troubleshooting the processor and KODAK MIN-R L Film System. They include:

- Cleanup film.
- Time-in-solution test tool.
- Emulsion number log.
- Split phantom test.
- Screen speed.

Cleanup Film

KODAK Roller Transport Cleanup Film 4955 (CAT No. 122 4310) is a specialized film designed to be used in conjunction with the processing environment. Each 14 x 17 in. (35 x 43 cm) sheet of film features a non-light-sensitive coating on both sides of the film base.

Cleanup film picks up lint, dirt, and other deposits and helps carry them out of the processor. For best results, one or two sheets should be processed.

Cleanup film is particularly useful to control a processing artifact called delay streaks. Cleanup film may be used in all processors, except those with area replenishment, which cannot sense this clear-based film.

Fogged or expired single- or double-emulsion film that has not previously been processed may also be used as cleanup film. Note that mixing films from different manufacturers in the same environment should be avoided, as undesired sensitometric changes may occur.

Any film used as cleanup film should be discarded after one use to avoid contaminating the developer solution with fixer and redepositing lint or dirt back onto the rollers in the processor. Contact your local Kodak representative for additional information about KODAK Roller Transport Cleanup Film 4955.

Time-in-Solution Test Tool

Films used for medical imaging should be processed in the processing cycle or cycles recommended for the particular film type.

The temperature of the developer solution and the length of time a film spends in the developer solution are important considerations in determining whether the film will be properly processed (optimal optical density and contrast). The length of time the film spends in the developer is known as developer time, development time, or developer immersion time. It is defined as the amount of time from the leading edge of the film into the developer to the leading edge of the film into the fixer.

A time-in-solution (TIS) test tool, which consists of a strip of clear blue film base from which all film emulsion components have been chemically removed and two white tape strips, may be used to verify the correct developer immersion time as specified by film and processor manufacturers. Note that motor speeds will vary slightly from processor to processor of the same type; the TIS tool should be used to check for times significantly more or less than the times listed by the processor manufacturer.

The procedure is as follows:

1. Remove the lid of the processor. A small magnet placed near the microswitch may be needed to allow the processor to operate without the lid in place.

2. Locate the approximately ¼ in. (6.3 mm) gap between the entrance detector crossover and the guide shoe. Also locate the gap between the developer-to-fix crossover assembly and the guide shoe.

3. Feed the test tool into the processor, placing the tool either along the film feed tray guide or in the center of the film feed tray, with the bottom of the taped T feeding first.

4. With a stopwatch in hand, get ready to begin timing when the black line drawn across the tape passes through the space in the entrance detector crossover.

5. Begin timing when the cross of the T reaches the same space. Either the top or bottom of the strip of tape may be used.

6. Stop timing when the same part of the cross of the T reaches the space in the developer-to-fix crossover assembly.

7. Repeat the timing sequence three times and take an average to determine the developer time.

8. The total processing time should also be checked and verified by measuring the amount of time either a mammography film (18 x 24 cm, with 24 cm of film travel) or a general radiology film (35 x 43 cm, with 35 or 43 cm of film travel, depending on the width of the processor) takes to transport through the processor. Time from the leading edge of the film into the processor to the trailing edge exiting the processor. Repeat the timing sequence three times and take an average to determine the total processing time.

Correct developer immersion time at a specified developer temperature is particularly important when processing mammography films, which are generally processed in standard or in extended processing cycles.

As previously discussed, KODAK MIN-R L Film should be processed only in a standard processing cycle.

The TIS test tool and instructions are available at a nominal charge by calling KODAK Parts Services at 1-800-431-7278 (716-724-7278), part No. 5B6497; instructions are also available separately (part No. 8B7020).

Emulsion Number Log

Film manufacturers designate each box of x-ray film with a multiple-digit emulsion number. This number provides important information such as which particular emulsion batch was used as well as which roll it came from, the specific part (slit) of the roll, and which variation of emulsion was used (variation code).

Keeping track of the emulsion number of the film used for processor quality control is generally done in every processor quality control program. It is also extremely advantageous to keep track of the complete emulsion numbers of all film used clinically, especially for mammography. Doing so allows film manufacturers to make comparisons in speed, contrast, D-max, etc., between current clinical images and images taken one or more years previously. Such comparisons may assist in troubleshooting image quality concerns.

The easiest way to retain this information is to start an emulsion number log. The log should contain the following information:

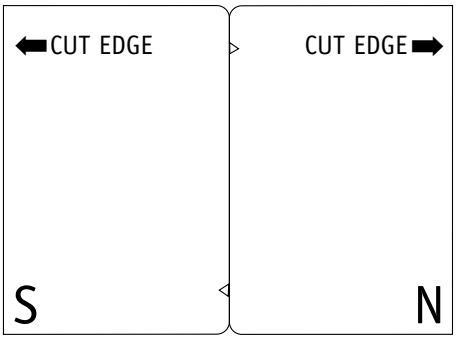
- Type of film.
- Date the box of film was opened.
- Expiration date.
- Film size.
- Complete emulsion number.
- Any other comments, such as which emulsions were used for processor QC or phantom images. Refer to the example above of a emulsion number log. Every time a box of film with a different emulsion number is opened, a new entry should be made in the log.

KODAK MIN-R 2000 Film

Date Opened	Expiration Date	Film Size	Emulsion Number	QC	Comments
12/22/99	02/01	18 x 24 cm	103 016 11	✓	
	02/01	24 x 30 cm	101 011 15		
2/02/00	03/01	18 x 24 cm	105 023 10	✓	Re-established QC

Split Phantom Test

A split phantom test should be performed to radiographically determine relative speed differences between two different boxes of film, one of which is suspected of being much faster or slower than the film in current use for either clinical films or for processor quality control. Speed comparisons made using a sensitometer may not accurately reflect the differences in speed between two films exposed by light from an intensifying screen.



The procedure is as follows:

1. Assemble the tools that are needed for the test:
   - A phantom used for mammography quality control testing.
   - The 18 x 24 cm mammography cassette normally used for the phantom test.
   - A piece of cardboard from the film box cut in half to use as a guide.
   - A pair of scissors.
   - A lead pencil.

The mammography x-ray unit and the processor will also be used for this test. Note that roomlight film-handling systems may not be able to remove the two pieces of film from the cassette or the films may not transport properly. If the roomlight film-handling equipment is installed through the darkroom wall and has a back door, the two films may be processed using that route. Alternatively, the two films may be processed in the processor used as backup for the mammography processor, or in any other processor available elsewhere in the facility.

2. In the darkroom, in total darkness to reduce any additional density added to the films due to long safelight exposure, cut a sheet of film from the current box in half by using the cardboard as a guide. (This can be done by lining up the 18 cm edges of the cardboard and film, with the film closest to the countertop and the card-board half on top. Use care in cutting the film in the dark.)

3. Place the film primary emulsion side up in the cover of the opened cassette with the film on the right side and the cut edge toward the right edge of the cassette; use a lead pencil to mark the corner N for normal.

4. Cut a sheet of film from the suspect box in half by using the cardboard as a guide.

5. Place the film primary emulsion side up in the cover of the opened cassette with the film on the left side and the cut edge toward the left edge of the cassette; use the lead pencil to mark the corner S for suspect.

6. Make sure the film edges in the center of the cassette are directly adjacent to one another and not overlapping before closing the cassette.

7. Place the cassette with the two film halves in the bucky (image receptor) of the mammography x-ray unit.

8. Place the phantom on top of the grid in the standard location used for mammography quality control testing.

9. Position the photocell beneath the center of the phantom (standard location), assuming the phantom exposure is always made using the phototimer.

10. Select the same technique factors usually employed when imaging the phantom (same kVp, etc.).

11. Make the exposure and process the two film halves immediately in the same manner (e.g., primary emulsion side up and on the right side of the processor). *NOTE: Daylight handling system should not be used to unload the cassette. Film halves should be manually fed through the processor.*

12. Use a densitometer to take two optical density readings in the center of the phantom, just to the right and left of the cut edges (one on the normal and one on the suspect film).

13. Calculate the density difference by subtracting the optical density value of the suspect film from the optical density value of the normal film. If the density difference is a negative value and the suspect film is darker than the clinical film, the suspect film is faster. If the density difference is a positive value and the suspect film is lighter than the clinical film, the suspect film is slower. According to the American College of Radiology (ACR) in *Recommended Specifications for New Mammography Equipment* (June 1995, pages 31–33):

- A density difference of 0.30 between any two films of the same type from the same manufacturer, exposed and processed together, is a reasonable maximum to be expected from manufacturing variability for films of roughly the same age and storage conditions.
- If the difference between the two film densities exceeds 0.30 at a density of approximately 1.25 (as specified by the test), then the film supplier should be contacted to determine the source of the problem.

Note that a difference of 0.30 at a density of approximately 1.25 may translate into a bigger difference for clinical films exposed at a greater optical density. For example, high-contrast mammography films, such as KODAK MIN-R L Film, are frequently exposed at an optical density between 1.50 to 1.70 in order to maximize contrast. The density difference at this optical density level may be greater due to the increased contrast.

Procedure for Uniformity of Screen Speed

Objective
To assess the uniformity of the radiographic speed of image receptors routinely used for mammographic imaging.

Caveats for Success
- Set aside enough film from a single emulsion lot to perform the test on all cassettes.
- Automatic Exposure Control (AEC) of the mammography x-ray unit must be performing within standards.
- Processor must be in control.
- Feed all films through the same side of the processor.
- Measure the optical density of the film in the same place on each film.

Required Test Equipment
- The image receptors normally used for mammographic imaging.
- Film of the type used for mammography. Note that the use of a single emulsion lot of film, and most preferably, film from a single box, is very important in obtaining useful results from this test.
- A 4.0-cm-thick cassette-sized phantom made of either acrylic or BR-12. Some provision should be made on the phantom to allow density measurements to be made in the same place on each of the test radiographs. If density measurements are not taken from the same location, significant variation can be obtained due to variation in beam intensity.
- A spot-reading densitometer.

Test Procedure Steps
1. Identify all of the image receptors (cassettes) of each size and type to be evaluated with some form of numbering system for further reference.

2. Select one of the cassettes and load it with a sheet of film from the box set aside for this test. Record on the data form the specifics of the image receptor being evaluated and the emulsion number of the film used for the test. This cassette will be called the control cassette.

3. Select the mammographic imaging mode and kVp most commonly used for clinical examinations (e.g., contact, grid, 28 kVp, Mo Filter) using an automatic exposure control (AEC), if available and used clinically.

4. Position the phantom on the cassette holder assembly (bucky) at a location over the image receptor that would be occupied clinically (breast). Place the compression device in contact with the phantom.

5. Using the imaging mode and kVp selected in Step 3, determine the ± density control setting (if photo-timed) or mAs (if manual) required to obtain an image optical density (O.D.) greater than 1.20, as measured in the center of the phantom image. Record this technique on the data form.

6. Load all of the mammographic imaging cassettes to be evaluated with film from the same box as used in Step 2.

7. Sequentially expose each cassette in the first half of the test group under the conditions determined in Step 5. It is useful to use lead numbers to identify the images. If AEC exposures are used, make sure that the lead numbers are not placed in the vicinity of the AEC detectors. Record the actual mAs for each exposure on the data form. It is important to ensure that the position of the phantom and AEC detector is unchanged during all exposures.

8. After the first half of the cassettes have been exposed, unload the film from the control (first) cassette and process the film. Reload, wait the appropriate time for air purge, and expose the control cassette to prepare a second control film. Continue testing the cassettes from the second half of the testing group, as noted in Step 7. Reload and expose the control cassette after all test cassettes have been exposed. This will result in three control films from the one cassette, from the beginning, middle, and end of the test sequence. If possible, additional measurements of the control cassette should be made, spread throughout the measurements of the test cassettes. This will greatly improve the reliability of the results.

9. Process the exposed films in the film processor routinely used for mammographic imaging. Process the films on the same side of the processor.

10. If more than one size or type of cassette is used for mammographic imaging, repeat Steps 1 through 10 for each. The same lot of film should be used across all cassette sizes if the results are to be grouped together as the same cassette type.

11. Measure the optical density at the center of the phantom on each of the processed images and record optical density on the data form. (Identify the center by diagonals "drawn" from corner to corner across the phantom image.) If possible, take several density measurements from the area immediately surrounding the center of the phantom and average them. This will eliminate errors due to film or processing artifacts.

12. The data should be recorded on an appropriate form (see page 24) and should be recorded in the order in which the cassettes were run. Accurate record keeping is vital to the interpretation of the test results.

Data Interpretation and Analysis

Using the measured densities from the three films exposed in the control cassette, calculate the standard deviation of the control film optical densities. If the standard deviation exceeds 0.05, the variability of the x-ray exposures or film processing is excessive and the screen speed uniformity test cannot be carried out adequately under these conditions. Corrective action should be taken to reduce this variability before assessing screen speed uniformity. If the standard deviation of the control films does not exceed 0.05, then determine the maximum and minimum optical densities from all cassettes. The difference between the maximum and minimum optical densities of a single size and type should not exceed 0.30. Corrective action is necessary for any cassette-screen combination that does not fall within this range.

Suggested Performance Criteria and Corrective Action

Any individual cassette-screen(s) within a given speed group of one size or type that does not meet the above criteria should be checked to try to determine the cause of the problem. One obvious item to check is misidentification of a cassette with the type of screen(s) it contains. Also, if screens of the same speed are contained with cassettes of different manufacturers, it is possible that variations in attenuation of the cassettes may cause significant variations in film density. Should no identifiable cause for image density variation be determined, it is reasonable to replace the cassette-screen(s) that results in optical densities outside the 0.30 O.D. range.

Uniformity of Screen Speed

Screen type:		Processor used:	
Film type:		kVp setting:	
Focal spot:		AEC density control	

Small Cassettes

Size:	cm
Film Emulsion #:	

Cassette ID#	Artifacts?	mAs	Density
Control Cassette:			
Mean of control cassette densities			
Standard deviation of control cassette densities			
Other Cassettes:			
Mean Density			
Minimum Density			
Maximum Density			
Density Range			

Large Cassettes

Size:	cm
Film Emulsion #:	

Cassette ID#	Artifacts?	mAs	Density
Control Cassette:			
Mean of control cassette densities			
Standard deviation of control cassette densities			
Other Cassettes:			
Mean Density			
Minimum Density			
Maximum Density			
Density Range			

Comments

Action Limit: **If standard deviation of control cassette densities is less than 0.05 AND density range exceeds 0.3, then corrective action is needed.**

Information Needed by Kodak to Facilitate Troubleshooting

When contacting Kodak for assistance with image quality concerns, having as much of the following information as possible will facilitate all troubleshooting efforts:

- Make and model of processor.
- Mix of film types processed.
- Volume of films (number of sheets per typical eight-hour day).
- Brand of chemicals (developer and fixer).
- Type of chemicals (e.g., premixed, automixed, or facility mixed).
- Replenishment rates (milliliters of developer and fixer, fully defined in terms of number and size of film, and length of film travel, e.g., 30 milliliters of developer and 30 milliliters of fixer per one 18 x 24 cm KODAK MIN-R L Film, single film feeding, 24 cm of film travel).
- Dates last and previous preventive maintenance (PM) of processor performed.
- Developer temperature.
- Current and previous emulsion numbers.
- Date the change or problem was noticed.
- Description of change (what was observed and who noticed it).
- Description of any unusual circumstances (e.g., films processed only 2 days per week, etc.).
- Optical densities of the 21 steps from the sensitometric strip.
- Characteristic (H&D) curve.
- Optical densities of the normal and suspect film halves from the split phantom test.
- Phantom optical density and technical factors used.

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Notes

Notes

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